US.8 S58s v.1 no.7

SOIL CONSERVATION

HENRY A. WALLACE
Secretary of Agriculture

H. H. BENNETT
Chief, Soil Conservation Service

VOL. I–NO. 7

FEBRUARY · 1936

ISSUED MONTHLY BY THE SOIL CONSERVATION SERVICE, DEPARTMENT OF AGRICULTURE, WASHINGTON

TWO CENTURIES OF ACCRUING TRAGEDY ALONG THE DAN RIVER

By P. F. Keil

The first white settlement in Virginia was made by Whitman in 1607 on the James River. Very few hunters and traders reached the Piedmont section before Colonel William Byrd II made the survey of the dividing line between Virginia and North Carolina in 1728. Colonel Byrd wrote a description of the river and its drainage area. Near the present site of Danville he found carved on a birch tree, "J. H., H. H., and B. B. lay here 24th of May, 1673." John Hatcher, Henry Hatcher, and Benjamin Bullington were early traders and famous woodsmen.

Colonel Byrd, in his description of the area, said:

Watershed of the Dan River above Schoolfield Dam, Danville, Va. Approximate area, 1,360,000 acres.

> Happy will be the people destined for so wholesome a situation, where they may live to fullness of days, and which is much better still, with much content and gaiety of heart.

Inviting Prospect

Colonel Byrd spoke of the Dan River Valley as the "Garden of Eden." Said he:

> The air is wholesome and the soil equal in fertility to any in the world. This charming valley will bring forth like the lands of Egypt, without being overflowed once a year. The grass in the river section grows as high as a man on horseback. The river, about 240 feet wide, always confined within its lofty banks, and rolling down its waters as clear as crystal. The stream, which is perfectly clear, runs about two miles an hour. The bottom is covered with coarse gravel, spangled very thick with a shiny substance that almost dazzles the eyes and the sand on either shore sparkles with the same splendid particles. At first sight, the sunbeams giving a yellow cast to these spangles, made us fancy them to be gold dust, and that consequently all our fortunes were made, but we soon found ourselves mistaken and our gold dwindled into small flakes of isinglass. However, this does not make the river as rich as we could wish, yet it makes it exceedingly beautiful.

43149—36

Throughout Byrd's History of the Dividing Line and The Secret History, he continually refers to the richness of the soil in the areas drained by the James, Meherrin, Nottoway, Staunton, and Dan Rivers with their tributaries. Such references as the following are numerous:

> The Soil we past over this Day was generally very good, being cloath'd with large Trees, of Poplar, Hiccory and Oak. But another certain Token of its Fertility was that wild Angelica (*Archangelica atropurpurea*) grew plentifully upon it.
>
> * * *
>
> That the Soil brings forth Corn Spontaneously, without the Curse of Labour, and so very wholesome that none who have the happiness to eat of it are ever sick, grow old or dy.
>
> * * *
>
> The Soil where the Locust Thicket grew was exceedingly rich as it constantly is where that kind of Tree is Naturally and largely produc'd.

Wild turkey, deer, partridge and other game was plentiful. The surveyors supplied their entire meat requirements with little effort. Cherries, wild plum, wild grapes, other berries, seed-bearing trees, plants, vines and shrubs furnished a good food supply.

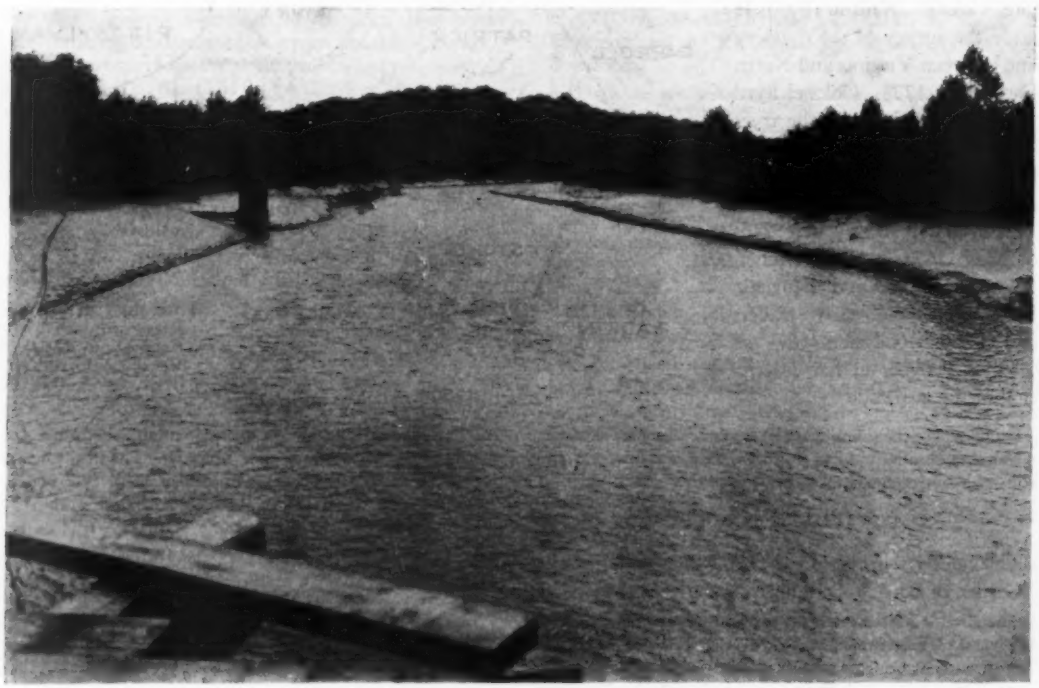
A camp was established by Colonel Byrd at Wynne's Fall. The planters came annually to fish for the sturgeon in the Dan, and to talk with old friends. A permanent settlement was not made in Pittsylvania County, however, until about 1746. Wynne's Fall, by an act of the Virginia Legislature November 23, 1793, became Danville. Colonel Byrd had named the Dan, and the legislature named the town on its banks for the "charming river" over which Colonel Byrd rhapsodized in his history of the Dividing Line. From this date on, the number of settlers increased rapidly until the greater part of the county was cleared. As shown by the records of tobacco sales in the clerk's office in Chatham:

> A list of tobacco records at Danville Warehouse from October, 1797 till September, 1798 one hundred and ninety four Hhds. and remain 34 in warehouse and 2116 pounds of Transfer tobacco. (A total of 275,716 lbs. of tobacco).

High Production

Quoting from historical collections of Virginia by Henry Howe, published in 1845 by Babcock & Co., Charleston, S. C.:

Looking upstream, east side of island and main channel of river. The structure at the left is the intake for the city water supply; when built in 1904 it was in the main channel of the stream.



Pittsylvania County, Virginia, was formed in 1767, from Halifax. It is 35 miles long and 26 broad. It is watered by the Staunton on the north, the Dan on the south, and Banister River in the centre: Much of the soil is excellent and produces annually over six millions of pounds of tobacco, besides heavy crops of grain. Danville is a large village on the Dan River, with a population of about 1500.

The canal of the Roanoke company around the falls of the Dan River is about one mile long, which affords eligible sites for manufactories to almost any extent, with abundance of water-power at all seasons. The river is navigable for batteax carrying from 7,000 to 10,000 pounds as far up as Madison, North Carolina, 40 miles distant. With some slight improvements, the river is supposed to be susceptible of steamboat navigation to the town.

In this same book we read:

Amelia County, Virginia. It is drained by the Appomattox River. The surface is agreeably diversified; the soil on the hills poor and usually much worn, on the bottoms fertile, and it has generally much deteriorated from its original fertility, owing to the injudicious modes of cultivation pursued by its early settlers.

Bedford County, Virginia. The surface is uneven and the soil *is naturally very* fertile, but has been injured by the injudicious cultivation of tobacco.

Campbell County, Virginia. Its surface is broken and its soil productive. Staunton River runs on its south and the James on its northwest boundary, *both of these streams are navigable for boats far above the county limits, thus opening a communication with Chesapeake Bay and Albemarle Sound.*

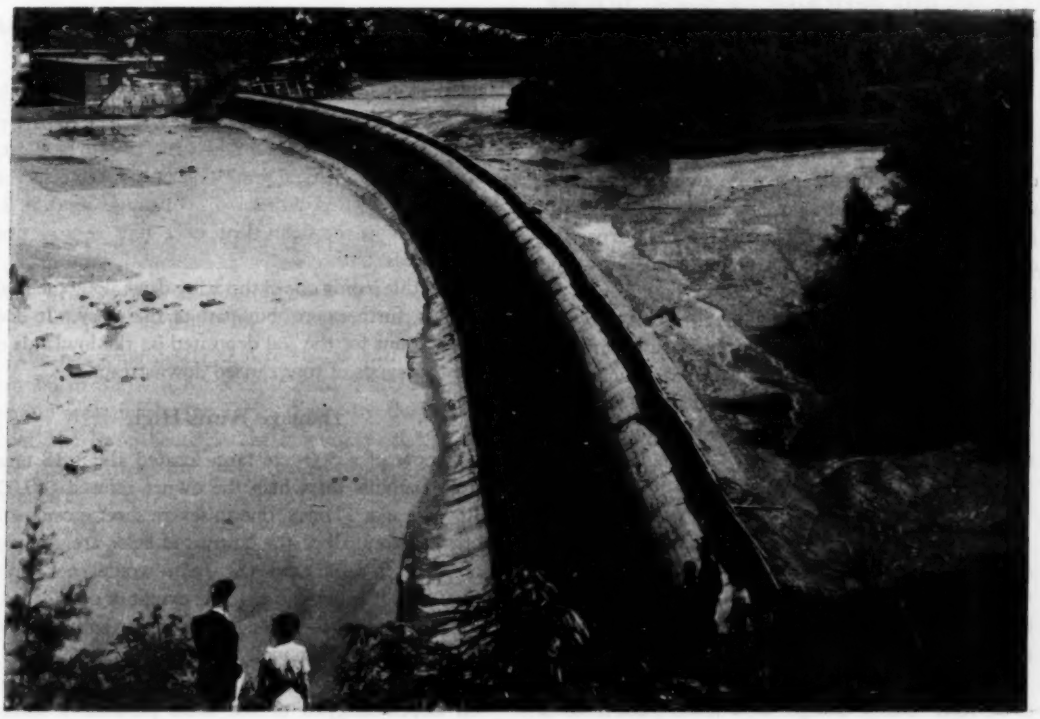
In 1845 Howe said of Rockbridge County, Va.:

Much of the soil is of superior quality and highly cultivated. It is one of the most wealthy agricultural counties in the state. * * * Spottsylvania County, Virginia. The soil on the streams is fine.

Erosion Takes Nearly Half

One hundred forty-two years have elapsed since Danville was named, and 189 since the first settlement was made in Pittsylvania County. It is estimated that 85 percent of the drainage area of Dan River was once cleared. The area above the Schoolfield Dam contains 1,360,000 acres, 1,153,000 having been cleared, and only 15 percent, or 204,000 acres, having remained in virgin forest. However, 40 percent, or 544,000 acres, has been allowed to go back to forest, due to erosion. Until recently, little thought had been given to the idea of holding the soil and plant food on the farms; consequently the soils have washed away.

View from north end of dam, with water drained off. The flood gates are raised every month to prevent the remaining water channels from being entirely filled with silt.



A silent reminder that erosion is a relentless foe.

Dan River and Smith's River have as their sources two beautiful springs within throwing distance of each other in Patrick County, Va., on the Blue Ridge Plateau over 3,000 feet above sea level. They are fed along their routes by other springs—all cool, clear, lovely.

This watershed, belonging to the Dan and its tributaries, drains four counties above Danville, Patrick and Henry in Virginia, and Stokes and Rockingham in North Carolina. It is 95 miles from source to Schoolfield Dam. The Dan is naturally clear, except in time of freshets, until after it leaves the plateau. In fact, it is clear until it enters Stokes County. From there on it is of reddish hue.

Conditions Radically Different

No longer can be seen the shiny glitter that once caught Colonel Byrd's eye. A swimmer emerges with a copper-colored skin. A fisherman reconciles himself to a few mud cats, suckers and carps; the clear-water game fish are not to be found below the plateau region.

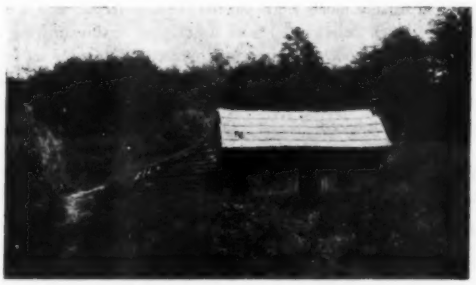
The Dan today is carrying millions of dollars worth of plant food and soil from the drainage basin; it is making farms poorer and poorer each year; families are being driven from their homes in order that they may make a living elsewhere; estates are being divided and sold. One is led to wonder what Colonel Byrd would say if he could live again and visit the one-time "Garden of Eden."

The Schoolfield Dam, just above Danville,furnishes evidence of the rapidity of erosion throughout the watershed. It was completed in 1904. It is 1,150 feet long, 35 feet high. Its backwater reaches 3½ miles up the river, forming a reservoir of 540 acres.

At the beginning this reservoir had an average depth of 17 feet. Many changes have taken place in these 32 years. An island has formed, occupying four-fifths of the reservoir, or about 400 acres, at an average of 3 feet above the usual water level. This island has existed long enough to be grown up with willow, elderberry, mulberry, birch, swamp dogwood, ash, red elm, maple, black walnut, sycamore, and other tree, the largest of them 20 inches in diameter.

Silt Washed Down

Only a narrow channel is left where there were once 600 acres of open water. The engineer in charge states that the flood gates have been opened regularly



Another relic of the past. Note the gullied road, now unused.

since 1920 in an effort to release some of the silt. This would seem to indicate that the greater part of the silt has been washed down the river. It is estimated that in about 16 years 432 acres of the reservoir have been covered with soil to an average depth of 19 feet. This is the equivalent of 1 foot of soil over 8,208 acres.

And this is only one of the many dams along the Dan! This is, furthermore, but part of the story. It does not account for the soil deposited on the lowlands or the thousands of tons carried downstream.

Damage Runs High

I know of a 500-acre farm located about 18 miles from Danville for which the owner refused $60,000 10 years ago. Today, due to severe sheet erosion and other factors, all of the cultivated fields are denuded of their topsoil, and the farm would not bring $10,000. It is obvious that the extent of damage from soil erosion in the Piedmont section will run into millions of dollars annually.

Thousands of farmers in this section are operating on slopes stripped of the more productive surface

layer and have only the slimmest opportunity to make a satisfactory living.

Virginia is primarily agricultural and the welfare of its population, urban as well as rural, depends to a large extent upon the general prosperity of the farming people. The number of people living on farms in Virginia in 1930 was 984,746, representing nearly 40 percent of the population of the State in that year.

Hastens Erosion

The type of farming practiced by most tobacco growers accelerates the erosional process. Scrub pine and broom sedge are nature's remedies for healing and reclaiming lands so damaged.

J. C. C. Price, agricultural agent of Patrick County told me that in June 1935 during a heavy rainstorm more than six acres of topsoil slid from one of the steep slopes covering rich bottom lands in the Dan River Valley between Kibler and Bell Spur.

Ararat River has its headwaters not far from the falls of the Dan in the Southwestern part of Patrick County. The Ararat here is a comparatively clear stream, but its waters become almost brick red after joining the Yadkin River in North Carolina.

This property has seen better days. Typical of the abandoned homes of the region.

The foregoing description of stream silting due to erosion in the Dan River watershed is applicable to similar areas in the territory drained by the Mattaponi, the Rappahannock, the Pamunkey, the James, the Appomattox, the New, the Nottoway, and the Meherrin.

This great economic loss is by no means confined to Virginia, for the same conditions may be found throughout the Southeast from Pennsylvania to Florida.

If we remember that it was only 189 years ago that the first settlers came to Pittsylvania County, that most of the soil wasting has occurred in the past century, and that 40 percent of the land once in cultivation has been destroyed for farming purposes, we are led to wonder if the remaining portion will be lost to agriculture within the *next* hundred years.

Yet there is hope. The remaining soil can be kept where it is and the majority of the water can be absorbed by the soil and saved for the crop, if the proper soil and water conservation practices are followed generally in the future.

BETTER PRICES FROM CONTROLLED GRAZING

By B. W. Allred

Two cowmen neighbors, separated only by wire fences, recently placed their calves on the Denver market.

The steer calves belonging to one of them averaged 336 pounds and sold for $7.25 per hundred pounds, or $24.36 each. The heifers weighed 336 pounds each and brought $6.25 per hundred pounds, or $21 each.

The market situation in the second case is as follows: The steers weighed 440 pounds and sold for $8.10 per hundred pounds, or a gross of $35.64 per head. The heifers weighed 408 pounds and sold for $7 per hundred pounds, or $28.56 each.

Breeding Similar

Age and breeding were similar in both cases. The owner of the lighter calves attributes the difference entirely to pasture conditions, as he had been trying to carry more cattle than could be handled with greatest economy. He holds that his net receipts would be greater from fewer cattle properly grazed than from his present system.

Notwithstanding its run-down condition, this house with its numerous additions is occupied by a family of 12.

Cause: An abandoned road encouraging formation of gullies, some of which have started to cut under oak trees. A scene in the Dan River country.

Consequence: Gully caused by water from State highway and from abandoned road shown above.

A FORMULA FOR CAPACITIES OF RESERVOIRS

By G. C. Dobson[1]

In calculating the silting rate of a reservoir it is necessary to determine the original capacity, the volume of sediment deposited, and the present capacity. It is also essential that these three quantities be in harmony; i. e., they must be computed by the same method.

In all except a few cases in which accurate contour maps of the reservoir have been available, field surveys have consisted of establishing numerous ranges on which measurements of water depth and silt thickness could be made. These ranges are survey lines of known length extending from shore to shore across the reservoir, and commonly tied into a triangulation network. Lacking original maps, the shore line at spillway crest elevation has been surveyed. As a result, in the majority of cases, the computer has been faced with the problem of finding these volumes from a map of the shore line of the lake at spillway crest elevation with a set of ranges and range cross-sections indicating original and present bottoms of the lake.

Capacities of natural reservoirs are, of necessity, approximations; the more extensive and accurate the survey, the closer the approximation. The data obtained by these survey methods yield values of sufficient accuracy to meet the desired objectives.

After looking over the formulas and methods used in similar cases it was decided to work out something to fit this particular case. These efforts resulted in the following formula:

$$V=\frac{A'}{3}\left(\frac{E_1+E_2}{W_1+W_2}\right)+\frac{A}{3}\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)+\frac{h_3E_3+h_4E_4+}{130{,}680}$$

where:

V=Original capacity, silt volume, or present capacity in acre-feet.

A'=The quadrilateral area; i. e., the area in acre-feet of the quadrilateral formed by connecting the points of range intersection with crest contour between the two principal or most nearly parallel ranges.

A=The lake area in acre-feet.

E=The cross-section area, in square feet, of original capacity, silt volume, or present capacity cut by bounding range.

W=Width of bounding range at crest elevation in feet.

h=The perpendicular distance from the range on a tributary to the junction of the tributary with the main stream, or if this junction is outside the segment, to the point where the thalweg of the tributary intersects the downstream range.

The subscripts to E, W, and h indicate the number of the range with respect to the segment.

The formula is general and covers all cases except the special case of the segment next to the dam where the effect of the shape of the dam does not lend itself to inclusion in the formula. The application of the formula is exactly the same for original capacity, silt volume, or present capacity and all quantities used, except the quantities, E, will have the same values.

The segments, or subdivisions, of the lake may be bounded by any number of ranges and intervening stretches of shore line. Areas with two ranges may have one or two stretches of shore line and areas with three or more ranges may be closed figures with no shore line or may have any number of stretches up to the number of ranges.

For each segment, the numbers of the ranges, which are the subscripts in the formula, will generally be taken so that no. 1 is the downstream range, no. 2 the upstream, and nos. 3 and higher are ranges on tributaries or arms of the lake. In cases where the range on a tributary or arm of the lake is nearer parallel to range no. 1 than the upstream range it is taken as no. 2 and the upstream range as no. 3.

It will be seen from the derivation of the general formula, as given below, that theoretically there must be at least two ranges in a segment. Where only one appears, as on a tributary or lake arm, no. 2 must be considered as a point at the extreme upper end of the arm. Here we have a range with zero cross-section area, $E_2=0$, and zero width, $W_2=0$, but A' is not zero. The quadrilateral area, A', in this case has one side, W_2, that is zero and has the shape of a triangle with W_1, as the base and the point of hypothetical range no. 2 as its apex. In this case the formula reduces to—

$$V=\frac{A'}{3}\left(\frac{E_1}{W_1}\right)+\frac{A}{3}\left(\frac{E_1}{W_1}\right)=\frac{A'+A}{3}\left(\frac{E_1}{W_1}\right)$$

[1] The author is assistant head, Sedimentation Studies, Division of Research, Soil Conservation Service.

The use of the formula for segments having two or more ranges is obvious; the quantities bearing subscripts greater than the number of ranges are equal to to zero and vanish.

Derivation of the Formula

The problem is to find a formula that will give the most probable values for original capacity, silt volume, and present capacity when only the lake area of the subdivision, the width and cross-section areas of the ranges, and the points where the thalwegs of the streams intersect the ranges are known. Seldom were more data available in the reservoirs computed. In using the general formula, the values of the quantities h for ranges nos. 3 and higher must be known in addition to the given data. To obtain these by scaling, the points of junction of the tributaries and the main stream must be plotted from judgment, using the shape of the shore line and the points where the thalwegs intersect the ranges as guides. These values of h may not be as accurate as desired, but the problem is to find the most probable from the available data.

When an engineer wants the most accurate value of the yardage in a cut, fill, or levee from cross sections, he uses the prismoidal formula. This formula gives exact results when the figure is a true prismatoid, and for many figures that are prismoids only by liberal definition, even going so far as to apply to the case of a sphere. In the problem at hand, the figure is never a true prismoid, but the formula makes a good point of beginning.

Consider, first, an imaginary segment with two parallel ranges and shore lines that are straight lines connecting the ends of the ranges. The most probable capacity of this segment can be represented by a prismoid having either rectangles or triangles, with areas equal to the actual areas, for end faces. The width, W, and the depth, $\frac{E}{W}$ or $\frac{2E}{W}$, vary uniformly from one end face to the other. These prismoids are shown in figures 1 and 2.

Using the notation of the general formula h' for the perpendicular distance between the ranges, and the subscript m for the computed midrange, the volume of either of these prismoids can be computed as follows by the prismoidal formula:

$$V'=\frac{h'}{6}(E_1+4E_m+E_2),$$

where

$$E_m=\frac{1}{4}(W_1+W_2)\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)$$

which gives

$$V'=\frac{h'}{6}\left[E_1+(W_1+W_2)\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)+E_2\right]$$

but

$$A'=\frac{h'}{2}(W_1+W_2),$$

so that

$$V'=\frac{A'}{3}\left[\frac{E_1+W_2}{W_1+W_2}+\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)\right]$$

It will be seen from this equation that the average depth of this segment is $\frac{1}{3}\left[\frac{E_1+E_2}{W_1+W_2}+\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)\right]$. This volume can be obtained, in the case of figure 1, by breaking the prismoid down into prisms, wedges, and pyramids and taking the sum of their volumes, but in the case of figure 2, this method cannot be used because the slope faces are warped surfaces. By resorting to the calculus the volume can be proved correct in the latter case.

If the prismoid shown in figure 2 is changed to the one in figure 3, it will be bounded by eight triangular, and one quadrilateral, plane surfaces and, by the prismoidal formula, will have the same volume. That this volume is correct for the new prismoid can readily be proved by breaking it down into three pyramids.

In building up the formula so far, only straight shore lines have been considered and the area used, A', is

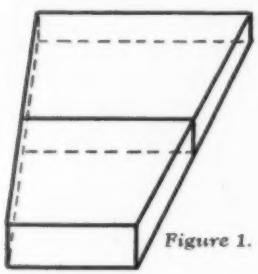


Figure 1.

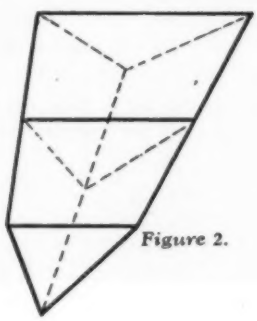


Figure 2.

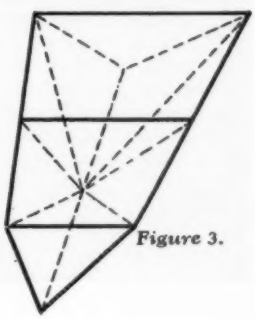


Figure 3.

the quadrilateral area of the general formula. The width of the lake is usually greater between the ranges than at the ranges. This is to be expected because the narrow places are the most practical places to locate ranges. In the large majority of cases, this makes the lake area, the, A, in the formula, greater than the quadrilateral area, A'. The total volume can be regarded as made up of the volume already established for straight shore lines, figure 3, plus the volume contributed by the excess area, $A-A'$. This latter volume might be regarded as equivalent to a wedgelike figure having the maximum depth line as its edge or a pyramid having the depth to the midpoint of the maximum depth line at its altitude. If we consider figure 3 as the most probable equivalent of the volume for straight shore line and picture the shore line as bent outward in curves the added volume takes the form of the pyramid . A study of the shape of contours in natural reservoirs provides convincing evidences that the pyramid is the form to use rather than the wedge for the excess volume. This gives for the excess volume

$$V''=\frac{1}{3}(A-A')\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)$$

This volume added to the volume for straight shore line gives

$$V=V'+V''=\frac{A'}{3}\left(\frac{E_1+E_2}{W_1+W_2}\right)+\frac{A}{3}\left(\frac{E_1}{W_1}+\frac{E_2}{W_2}\right)$$

From the form of this equation and from the shape of the figure developed as the equivalent of the most probable volume, it will be seen that, had it been self-evident that this was the shape to use, the above formula could have been derived by taking the sum of the volumes of three simple pyramids.

When tributaries enter the subdivision, or arms of the lake are cut off by ranges, there will be more than two ranges to consider. The formula developed for two ranges is the sum of the volumes of three pyramids with bases equal to the lake area and the two end areas. The altitude of the latter two are automatically cared for in the quadrilateral area, A'. The third and higher numbered ranges will also enter as pyramids with the range areas as bases and altitude to be determined. Bearing in mind that the shape used in obtaining the most probable volume was an equivalent shape and not the actual shape, a study of natural conditions indicate that the altitude should be the perpendicular distance from the range to the junction of the streams if the junction is inside the subdivision or, if not, to the point where the thalweg of the tributary intersects the lower range.

All the foregoing assumes that ranges nos. 1 and 2 are parallel, a condition seldom encountered in practice. The only part of the formula affected by diverging ranges is the expression involving A' as a direct factor. The computation of the error caused by this condition for any segment is impractical because it involves the unknown location of the intersection of the thalweg with an imaginary mid-range. Careful investigation of it indicates that this error is insignificant up to 10° divergence of ranges and that it tends to compensate in the sum of the volumes of the segments.

SUMMARY

The formula described in this article was developed specifically for computing original and present capacity and silt volumes in storage reservoirs. Surveys of silting in representative reservoirs throughout the United States are being carried on as part of the research program of the Soil Conservation Service through the Section of Sedimentation and Hydraulic Studies. The objective of these studies is measurement of depletion of water-storage resources of the country as a result of silting and to correlate silting rates with climate, soils, slope, and land use in the tributary watersheds. Through January 1936 detailed surveys of 26 reservoirs have been completed. In most of these, adequate, original maps of the reservoir basin were lacking, and the survey methods available at reasonable cost consisted of accurate soundings, silt thickness measurements, and crest-line contour maps. The above formula uses the data thus obtained to derive volumes with the maximum of accuracy which such data allow.

Fifty million acres, once cultivated in the United States no longer produce crops.

Three billion tons of soil are washed and blown from our fields annually.

Four hundred million dollars is lost to farmers in soil fertility annually.

SINKHOLE TERRACE OUTLETS IN MINNESOTA

By Loyal Van Doren

Sinkholes of many sizes and shapes are scattered liberally over portions of the Deer-Bear Creek area in Minnesota. A network of underground waterways undermines parts of this section, which has a peculiar limestone formation. The sinkhole, as the name implies, is formed by the sinking of a small area of land which has been undermined. The hole grows larger by surface erosion, which washes down the sides and by further sinking of the bottom due to the action of the water on the underground channels.

Sinkholes vary from 20 to 150 feet in width and from 8 to 35 feet in depth. They are, as a rule, shaped like funnels and sometimes have openings into underground caverns, limestone caves and waterways large enough for a man to enter.

Some farms in this part of the area may have one or two sinkholes which do little damage, but there are other places where as many as 20 such holes have been found, eating up as much as 5 acres out of a 40-acre tract.

Terracing for Erosion Control

Terracing is a suitable and practicable means of controlling erosion on many of the large cultivated fields here, but the cost of terrace outlets is sometimes prohibitive. Quite often these sinkholes can be conveniently used to dispose of the water from terraces, since they occur at random over the fields—on hilltops, on hillsides, or in waterways.

The bottoms of the sinkholes are unstable; therefore, the best way to dump any appreciable amount of water into the hole is to drop it directly over the center. The water is brought as far as possible with a permanent sod or masonry flume and then carried the rest of the way in a creosoted lumber flume or corrugated culvert. The latter is preferable because it is more durable.

Creosoted lumber flume used to drop water into sinkhole. This flume has masonry head and cut-off wall.

The growth of another sinkhole stopped by a diversion dike. This dike has a creosoted lumber core wall 32 feet long and 8 feet deep to prevent damage by woodchucks and gophers.

How Flumes Are Built

When creosoted lumber is used (as in the illustration) the flume is double-planked and the upper end is set into a masonry head wall. The middle is supported by creosoted posts and masonry footings. The lower end is held up by posts and footings placed back from the center of the hole on a solid foundation or by beams carried across to footings on the opposite bank. The flumes are usually made in two sections, supported independently of each other. The upper section drops the water into the lower section, but is not in any way attached to it. This is because sinkholes are treacherous. The bottom may sink farther or spread more than is expected, and if the lower section settles or fails, it will not, when constructed this way, take with it the part which is set into the head wall.

Considerable damage is often done to valuable farm land by large gullies which eat back from sinkholes—especially when they are in waterways. The general practice of the farmers in this area is to keep the banks of the sinkholes covered with vegetation. The large gullies which cannot be controlled by vegetation can be controlled by the use of diversion ditches or dikes around the gully which empty into the sinkholes in the manner just described.

REGRASSING THE SEMIARID PLAINS

By C. R. Enlow [1]

Many species of native grasses are of potential value for reseeding the depleted areas of the Great Plains and some of the more important grass seeds can be harvested from present stands. While it seems proper to favor in general the use of grasses in the areas where they are indigenous, experience teaches the disadvantage of restricting seeding to the established boundaries. Buffalo grass is a notable example of a grass indigenous to the Great Plains which has been growing for years in Washington, D. C., in Vermont, and in California. For the time being, however, our recommendations for seeding are based on the area naturally occupied by the grass.

Undoubtedly, the grass that presents the best possibility for harvesting and use in reseeding is *Agropyron smithii* (western wheat grass of the Great Plains and bluestem of the intermountain region). The grass is found in practically every State west of the Mississippi River and, to a lesser extent, east of the Mississippi. It is a fine native hay, and grows in almost pure stands from Montana to Arizona and New Mexico. Thousands of acres of fine stands are found in Nebraska and southern South Dakota, and in this section the Soil Conservation Service harvested nearly half a million pounds of seed for use on western projects. The grass grows like wheat and can be harvested with a combine, but naturally the land must be removed from grazing or haymaking and held for seed production. The seed is fairly large, which adds to its desirability for seeding on land with limited rainfall. *A. smithii* has underground stems, and spreads by this method, but is not a pest like its near relative *Agropyron repens*, the troublesome quackgrass. Farmers and seedsmen of Nebraska say that the grass-seed crop of 1934 was the best in 20 years.

Valuable for Grazing

Agropyron spicatum (bluebunch wheatgrass) is a good grass native from Washington to northern California, and east as far as Colorado. It was one of the valuable grazing grasses of the Palouse wheat country of eastern Oregon and Washington before that land was put to the plow and is still found in excellent stands in many places throughout the semi-dry areas of the Northwest.

Several thousand pounds were collected during the past season for planting on erosion-control projects in the Northwest. Where the land is sufficiently smooth this grass can be harvested with a combine, header or stripper. *Festuca Idahoensis* (bluebunch fescue) is another desirable grass in the dry lands of the Northwest that can be harvested and handled similarly to this one.

Andropogon scoparius (little bluestem) and *Andropogon furcatus* (big bluestem) occur practically everywhere in the country except the far West, and are especially valuable in the Flint Hill region of Kansas. These are the principal grasses of that fine grazing country, used for many years to fatten Texas and Oklahoma cattle for the Kansas City market. Their worth is recognized all through the eastern Great Plains, but only recently has the possibility of reseeding been explored. Ours was the first large-scale harvesting of seed. We found that ordinary farm machinery can be used toward this end, but difficulties are met in the threshing as the seed is awned and fuzzy or hairy. The bulk of the seed was harvested with power strippers, thus avoiding the necessity of threshing. Curiously enough, the bluestems, where they are found growing in the Eastern States, including New England, are practically worthless for hay or grazing.

Important in Dust Bowl

Buchloë dactyloides (buffalo grass) is one of the most interesting and desirable grasses as it formerly occupied much of the land from which the dust storms originated last year. It has always been highly regarded for grazing. It retains its palatability and nutritive value during the winter months after it has become brown and dry.

Buffalo grass occurs all through the low rainfall belt from Montana and North Dakota to Texas, although it is not abundant north of Nebraska. It is at its best in western Kansas and eastern Colorado. It seldom grows more than 3 or 4 inches tall, and has both male and female plants. The male flowers rise above the grass, appearing as ordinary seedheads and the female flowers occur near the ground where the seed is formed. Frequently, quite large patches of exclusively one type are found, perhaps originating from a

[1] The author of this article is in charge of the agronomy section, Soil Conservation Service.

single plant. Our attempts to harvest the seed have been discussed in other articles.

Buffalo grass has been reestablished successfully by scattering small pieces of sod at intervals of several feet. It spreads very rapidly by prostrate runners which readily take root when sufficient moisture is present. This method is thought too expensive, however, for extensive use.

Reseeds Readily

Bouteloua gracilis (blue grama) is a companion to buffalo and is often confused with it. It extends farther north and is found in abundance in North Dakota and Montana. Blue grama presents a much better possibility for reseeding than does buffalo, as the seed can be gathered with bluegrass strippers. Although yields are low, 80,000 pounds of seed have been collected for use on wind erosion control projects by bluegrass strippers and an ingeniously devised power stripper which will cover 35 acres per day. Omitting the western wheatgrass, the major portion of the seed of all species has been collected with the power strippers. Other gramas that are of value but scarcely as promising as blue grama, are *Bouteloua eripoda* (black grama) which occurs in western Texas and New Mexico; *Bouteloua curtipendula* (side oats grama), which is widely distributed but grows in somewhat scattered areas, thus presenting difficulties in harvesting; and *Bouteloua hirsuta* (hairy grama), which is found with buffalo grass and blue grama, but generally is not so aggressive nor so abundant as either.

Harvested by Ordinary Machinery

Sporobolus wrightii (sacaton) is an excellent grass for reseeding in dry regions of Arizona and New Mexico, and can be harvested with ordinary farm machinery. It is very desirable hay in that section. *Sporobolus airoides* (alkali sacaton) is a widely distributed related species that is also desirable for reseeding. A very large quantity of seed of these grasses is desired, and a considerable quantity has been harvested. *Sporobolus cryptandrus* and *Sporobolus asper* are two other species of the genus commonly called "dropseed" that are widespread in the West and offer possibilities in range reseeding work. A fair quantity of seed has been collected for trial plantings.

Oryzopsis hymenoides (mountain rice or Indian ricegrass) is excellent for dry land, and is found throughout the length of the Great Plains and west to the Pacific coast. It presents commercial possibilities, but occurs generally in scattered stands. The seed can readily be harvested with ordinary machinery, but presents a difficult germination problem.

Good for Hay

Sorghastrum nutans (Indian grass) is a very good hay and grazing grass that occurs in mixture with the bluestems, and is a particularly valuable constituent of bluestem pastures and meadows of the eastern Great Plains from the Dakotas to Texas. In harvesting bluestem seed, some mixture with Indian grass seed is almost a certainty, and desirable, as mixtures usually give a longer grazing period or greater yields of hay. Indian grass seed has long twisted awns or beards, and is fuzzy, placing it in the class of seeds that are naturally difficult to thresh, clean, and sow with machinery.

Stipa comata (needle thread) is a rather common grass that occurs in semidry areas throughout the West, and is an important grazing plant. *Stipa spartea* (porcupine grass), a near relative, is found in the Dakotas and Nebraska and east, under more humid conditions. Both are good grazing grasses. Their seed has been gathered with strippers. The collecting season is short, however, as the seed soon falls to the ground after ripening. Frequently, when the *Stipas* (often called needlegrasses as a group) are found in native meadows, haying is delayed until the seed falls to the ground as the long twisted awns and sharp-pointed seed are very undesirable in hay and sometimes cause injury to livestock. Nature has arranged for this grass to plant its own seed, and it is possible when the dew is drying from the rays of the morning sun, to watch the awns twist and untwist each movement causing the sharp-pointed seed to burrow further into the soil, until finally the awns break and blow away. While there are more desirable grasses, the needlegrasses should not be neglected in the attempt to improve the vegetative cover of the western range.

Adapted to Dry Plains

Hilaria jamesii (galleta) is a very valuable grass of the deserts and dry plains of the Southwest. The genus *Hilaria* has very few species, but *Hilaria jamesii*, in company with *Hilaria mutica* (tobosa) and *Hilaria belangeri* (curly mesquite) play a very important part in supplying grazing for livestock in the dry lands from western Texas to southern California. Seed can be gathered by machinery, and

where good areas of these grasses can be found, strippers can be used if the terrain is sufficiently level to allow the use of machinery. Curly mesquite is similar in appearance to buffalo grass, and is often confused with it.

Koleria cristata (junegrass) is an important constituent of the flora of our western ranges. It has a wide adaptation, being found from New England to California and south to Texas, although it does not occur in our Southeastern States. Generally it occurs in mixture with other grasses, and is a desirable addition. The seed matures quite early but does not shatter badly, and can be readily stripped.

Also Show Promise

It is impossible to mention here all the grasses that are possibilities in the erosion control program, but such grasses as *Redfieldia flexuosa* (blowout grass) and *Calamovilfa longifolia* show promise for the sand dunes of Nebraska, Kansas, and adjoining territory: *Ammophila breviligulata* (American beachgrass) for the coastal sands of the West and the Northwest, as well as for the Great Lakes; and *Puccinellia nuttalliana* (nuttall alkali-grass) and *Distichlis stricta* (desert saltgrass) for the alkali lands from Washington and Montana to Colorado.

In this discussion of our native grasses adapted to dry-land use, not commercially available on the market, it is scarcely fair to omit the few grasses that are available in more or less limited quantity, merely because three out of the four so used are not native. *Agropyron cristatum* (crested wheatgrass) is ideal for all the northern country, but it has not been grown successfully south of northern Kansas, and the seed is very high in price due to the limited quantity available. *Bromus inermis* (smooth bromegrass) and our native *Agropyron pauciflorum* (slender wheatgrass) are also confined to the Northern States due to their inability to live through the summer weather from Kansas south to Texas. The last three are the best commercially available grasses for seeding in regions of low rainfall from North Dakota to Nebraska and west. At high elevation they can be seeded farther south.

Poa bulbosa (bulbous bluegrass) has been growing successfully for several years in Oregon and Washington and northern California and undoubtedly has real possibilities in the dry lands of southern California, Arizona, and New Mexico, as on a recent plant exploration trip to Turkey it was found growing everywhere in the interior deserts, and almost to the shores of the Mediterranean within a few miles of citrus and palm trees. *Poa bulbosa* is adapted to regions of winter rainfall. The grass emerges in the fall, remains green all winter, and matures a seed crop in May and June, after which the tops die, but the bulbs remain alive in the soil, ready to send up shoots at the first fall rain.

Outlook Promising

The outlook for commercial seed production of our native grasses is most promising. Many trial plantings have been made the past 2 years and excellent seed crops have been harvested. Blue grama planted in rows at San Antonio, Tex., last spring gave two good seed crops during the summer. The bluestems, Indian grass, range mesquite, switchgrass, western wheat, and many others have shown their ability to produce excellent crops of seed the same season as seeded. It seems apparent the production of grass seed adapted to our semiarid regions offers a real source of income for farmers who are interested in this line of work.

The Soil Conservation Service is making a determined effort to meet the need for immediately covering a portion of the dry regions of the West with permanent sod, through the use of native grasses now found in the various regions and by working on a large scale hopes to sell the idea to the farmers, who may harvest the seed as a source of income and thus advance the erosion-control program in a few years far beyond what the Soil Conservation Service might accomplish by itself in a generation, as, after all, the solution to erosion in the western country must be through the use of vegetation.

One hundred and twenty-five million acres in the United States have lost their best topsoil.

Bluegrass sod, experiments at the Missouri Experiment Station show, holds back 137 times as much soil on a 3.7 percent slope of Shelby silt loam as bare ground. This rate of erosion points to the removal of a 7-inch soil layer in 24 years from bare ground and 3,547 years from sod.

MOISTURE MEASUREMENTS POINT WAY TO WIND-EROSION CONTROL

By O. T. Williams

When hunters first came to the high plains country, they found little evidence of wind erosion. The only damage was along stream beds where the action of water and wind had prevented nature from establishing covering. The rest of the land was protected by vegetation.

Only in the last few years has wind erosion in this area become a problem. This is due to the great expansion of agriculture, the growing of crops not resistant to erosion and the improper management of crop residue. There were periods of low rainfall before this land was placed in cultivation, but the vegetative cover held the soil and harbored the moisture until the rains began again.

It has been demonstrated on the Dalhart, Tex., project that wind damage can be controlled by use of erosion-resistant crops and the wise management of crop residues. Since water is an important factor in the production of these crops, it is necessary to make use of all that is available. This can be done in different ways. Important methods are: (1) Addition of organic matter; (2) proper tillage methods, and (3) control of run-off water. The latter is the leading factor in this area.

H. H. Finnell ran an experiment at Goodwell, Okla., on heavy silt loam planted to milo, which proves the value of a water-conservation program. He had three plots on unterraced land. No effort was made to control run-off water. Each plot was planted to a different variety of milo. A record of the total pounds of dry matter was made for each plot. The following was produced: Plot 1, 2,239 pounds; plot 2, 2,276 pounds; and plot 3, 2,426 pounds. The average was 2,313.6 pounds. These were produced with 17.3 inches average annual rainfall.

Records were kept to determine what became of the rainfall and the percentage which is available for crop production. Of the 17.3 inches of rainfall, it was found that 5.3 inches came in small rains that were ineffective for crop use. Out of the 12 inches which got as far as the subsoil, 2.2 inches ran off to the flat lakes. Of the remaining 9.8 inches, 6.05 inches were lost through natural evaporation or evaporation caused by tillage. Only 3.75 inches of water was available for plant growth.

One acre-inch of water weighs 226,270 pounds. The available water on each plot was 848,512.5 pounds.

Since the average production of dry matter on the plots was 2,313.6 pounds and 848,512.5 pounds of water was available, it was assumed that 366 pounds

(Continued on next page)

CONTOUR LISTING SAVES SOIL AND MOISTURE

The effectiveness of contour ridges in conserving moisture is shown by measurements taken at the Panhandle Agricultural Experiment Station at Goodwell, Okla., on May 17–18, 1935, when 1.79 inches of rain on land not listed on the contour penetrated only 8.75 inches, while the penetration on contour-listed land was 20.33 inches.

Terraces doubled the depth of penetration, yet contour ridges without terraces conserved more water than terraces without contour ridges. The terraced land had a penetration of 16.04 inches. Land terraced and ridged on the contour had the greatest penetration, 21.69 inches.

Disking was found to increase the penetration very little, less than one-half inch in this experiment. Contour chiseling caused an increase in penetration of 5.49 inches.

Erosion was less on contour-ridged land than on any other. All run-off water moved slowly, reducing to a minimum the wastage of soil.

Growing cultivated crops on the contour has advantages like those of contour ridging wheat land. The row ridges hold the rainfall where it can be utilized for plant production rather than permitting it to run off the fields rapidly, carrying away large quantities of soil.

MOISTURE MEASUREMENTS

(Continued from preceding page)

of water were required to produce 1 pound of dry matter.

Other experiments by Briggs and Shantz in Colorado show that 1 pound of dry matter of milo can be produced from 331 pounds of water. These experiments were made under laboratory-controlled conditions, while the work done by Finnell was under field conditions.

Effect of Terracing

Another series of experiments by Finnell shows that less evaporation occurs on terraced land than on unterraced. He found that the percentage of evaporation on unterraced land was 68.8 percent and on terraced land was 65.5 percent.

If the 2.2 inches which ran off the milo plots had been controlled by terraces and contour tillage, 0.759 of an inch more moisture would have been available for the production of milo. This would have added 172,870.28 pounds of water to each plot. Assuming that 1 pound more dry matter would have been produced by each 366 pounds of added water, the increase in production of dry matter would have been 472 pounds. This would have increased the average to 2,785.6 pounds, an increase of 20.4 percent. These yields were in pounds of total dry matter, including both grain and forage. Yields of wheat grain were increased 34 percent by saving the run-off water. The proportion of grain to straw increased as the number of successful crops increased. The close check between the water utilization by milo under controlled conditions and under field conditions indicate a high productive efficiency for the plains area.

In summary, it may be said that the use of agronomic practices which contribute to the amount and continuity of vegetative covering will aid in controlling wind erosion. The conservation of run-off water aids in controlling wind erosion and also increases the immediate profits of the farmer.

The South African Farmer reports that in the year ended August 1935, 5,500 applications for assistance had been received by the South African Department of Agriculture, which is making an effort to control soil erosion.

Erosion has caused streams to dry up, resulting in the disappearance of fish, animal and bird life.

A NEW JERSEY CONVERT TO TERRACING

The continual gullying of his fields and sedimentation of his meadow made Fred H. Totten of the Raritan-Neshanic River area welcome the coming of the Soil Conversation Service to New Jersey in the spring of 1935. He became the first farmer in the State to sign a cooperative agreement.

It was when his gullies were being filled preparatory to terracing that Mr. Totten declared that he had hauled more than a thousand loads of dirt back onto the field in the 15 years he had been on the place.

"Heavy rains have always washed gullies there," he said. "I know I have lost a lot more soil than I have hauled back. I only loaded up some that landed on the meadow below and used it to fill in the worst washed places. It was back work, not brain work. I couldn't keep the dirt on the hillside after I put it there."

Mr. Totten expects the new terraces, together with other conservation practices, to protect his farm successfully in the future.

The other day as he stood on his terraced field, he said:

"The fellow who farmed this place before me was here a while back. He is an old-timer and doesn't think much of some of the new ways of doing things, but he was interested in looking over this terracing. He said it would be a good thing if it stops the washing, for he did his full share of hauling, too."

Fred H. Totten, first to sign cooperative agreement in New Jersey, with Harry Holcombe, of Soil Conservation Service.

More than 300,000,000 tons of rich soil are dumped from the fields of the Mississippi Valley into the Gulf of Mexico each year.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

A contribution from the Soil Conservation Service Library

RANGE AND PASTURE MANAGEMENT. By Arthur W. Sampson, M. A., Ph. D. 1923.

REVIEWER'S NOTE.—This book, although not of recent publication, is of such current and fundamental importance to many of our workers that a review if regarded as being worth while at this time.

Grazing lands and the livestock industry, the judicious utilization and management of public and private lands upon which the future of the industry depends, is an economic problem of tremendous importance. Dr. Sampson's book provides systematic instruction for those who desire a practical working knowledge of the subject, as well as for those who wish to follow technical grazing management and improvement as a profession.

Opening with a reconnaissance of pasture sections in the United States, their native grasses and forage plants, their water availability, and methods used in the past for their improvement and protection, the author prepares the student for the substance of the book—practical instruction in new and scientific methods for correcting overgrazed pastures and timberlands and the declining forage yield.

Reseeding on western grazing lands is treated in detail, as well as plant introduction on arid lands, on mountains, and in semihumid sections. From mountain reseeding tests conducted in every State west of the Texas and Dakota line, with plots located where need for forage was greatest and on elevations ranging from 4,000 to 11,000 feet, by far the best results were obtained with timothy, 64.4 percent of all trials being successful or partially so. Next in order of successful results were Hungarian bromegrass with 58.14 percent, perennial ryegrass with 50 percent, Italian ryegrass with 37.5 percent, Kentucky bluegrass 31.82 percent, and red top with 33.33 percent.

Other phases of the subject which are given exhaustive treatment are: Methods of preparing and reseeding burned-over lands; how to graze newly seeded pastures; revegetation by deferred or rotation grazing; grasses and broad-leaved herbs for restoration; plant indicators for recognizing and correcting worn-out lands; principal introduced forage grasses and nongrasslike forage herbs. A useful plant-indicator list is arranged according to the natural grass or weed stage, first or early weed stage with Douglas knotwood (*Polygonum douglasii*) topping the list, second or late weed stage with blue foxglove (*Penstemon procerus*) leading, mixed grass and weed stage with small mountain porcupine grass and yellowbrush conspicuous, and the climax herbaceous stage when the wheatgrasses are predominant.

For the control of erosion on range and pasture lands, Dr. Sampson suggests cover plants, especially on hillsides, as the safest possible insurance against erosion and consequent damage. He urges the avoidance of overgrazing, or too early grazing, control and distribution of livestock, terracing and planting, and the construction of dams.

A chapter on the burning over of pasture lands emphasizes the danger of such practice, not only from the standpoint of engendering wide-sweeping and devasting fires but because of its destructive effects on forage production through impoverishment of the soils.

In the book are comprehensive chapters on stock-poisoning plants and their control. Important families of such plants are listed, described, and discussed as to methods of eradication. Among poisonous plants described and illustrated are the toxic milkweeds, the Gambel oak (*Quercus gambelii*) and shinnery oak (*Q. harvardi*), laurels, woody aster, aconite, ergot (a parasitic fungus), and the downy, hairy, and red bromegrasses whose sharp awns at seed maturity penetrate and cause sores and inflammation of skin, eyes, mouth, throat, stomach, and intestines of grazing animals.

In part 4 those interested in the technical management of pastures will find improvement research methods clearly outlined; also, complete directions for making a grazing reconnaissance. The "forage acre" formula is given, discussed, and explained. Research methods in revegetation, including plot procedure, are described and designated, and there are many tables, drawings, and illustrations for clarification of the subject.

At the close of the book is a 26-page condensed outline for practical and professional instruction in pasture and livestock management. Important features are the bibliographies at the ends of all chapters; grazing tables according to States, years, and increase; numerous illustrations from originals; and, in table form, the plan for revegetation by deferred and rotation grazing. The book includes a complete index to all references and subject matter.

Owing to the fact that the library has but one copy of this book, only short-period loans can be extended.

FORESTRY AND SCHOOL STUDIES, A CORRELATION FOR ELEMENTARY SCHOOLS. By E. V. Jotter. January 4, 1933.

Presents various phases of forestry in such a way that the subject may be introduced into the curriculum by correlation with arithmetic, reading, language, drawing, geography, history, and nature study. A study of trees and forest products; forest-fire control; conservation; insects, fungi, and other tree enemies; forests, water, and soil; national forests; starting a community forest. Includes teaching references and notes on 35 forestry publications. The appendix contains a plan for improving rural school grounds, with references, and the Municipal or Community Forest Act 217 of the Public Acts, 1931, of the State of Michigan.

PLANT PROPAGATION. By Alfred Carl Hottes. 1934.

This is a handbook for the plant propagator. In it are to be found the answers to 999 questions on the production of plants. There is much useful information on such subjects as plant breeding, seeds, cuttings, bulbs, grafting, fruit stocks, annuals, ferns, orchids, roses, tree shrubs and woody climbers, conifers, and evergreens. 265 illustrations. Index to plant names and general index.